

**BIOLOGY AND LARVAL TAXONOMY OF *EUCELATORIA BRYANI*
SABROSKY AND *E. RUBENTIS* (COQUILLETT) (DIPTERA: TACHINIDAE)**

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Abstract.—The tachinid flies *Eucelatoria bryani* Sabrosky and *E. rubentis* (Coquillett) are similar in their reproductive behaviors and will mate with one another under laboratory conditions; however, sperm is not transferred. Both species parasitize noctuid caterpillars, with the host range of *E. rubentis* being about four times broader than that of *E. bryani*, which is essentially restricted to *Heliothis virescens*, *H. subflexa* and *Helicoverpa zea*. Larvae of the two species can be separated from one another as second and third instars primarily by the shape of the dorsal cornu of the tentoropharyngeal sclerite. Both tachinids offer great promise as biological control agents of noctuid pests.

Key Words: Diptera, Tachinidae, *Eucelatoria*, *Heliothis*, *Helicoverpa*, host-parasite relations

The Tachinidae comprise the largest family of parasitic Diptera and have great potential economic importance as biological control agents. However, of the approximately 8000 described species of Tachinidae in the world, most are only known on the basis of adult morphology. Often, the characters used for distinguishing species or genera are subtle and of uncertain biological importance (Wood 1987). This lack of information constrains the use of tachinids as biological control agents, a problem that could be alleviated by information on other life stages and biological traits.

Eucelatoria bryani Sabrosky and *E. rubentis* (Coquillett) are two potentially important biological control agents (Knipling 1992). These two tachinids are sympatric across the south-central USA and north-eastern Mexico. The geographic range of *E. bryani* extends from western Arkansas and eastern Oklahoma, south and west to Arizona and Mexico (Jackson et al. 1969,

Young and Price 1975, Sabrosky 1981, Steward et al. 1990). *Eucelatoria rubentis* occurs across the southeastern USA from Delaware south through Florida, and west to Arkansas, Texas and Tamaulipas, Mexico (Sabrosky 1981). *Eucelatoria bryani* and *E. rubentis* can be differentiated on the basis of adult characters (Sabrosky 1981). Here we provide further diagnostic information by presenting the larval taxonomy and a synopsis of biological characters for both species.

MATERIALS AND METHODS

Our colony of *E. bryani* was derived from material originally collected from corn (*Zea mays* L.) in Arizona and later cultured in USDA laboratories in College Station and Weslaco, Texas. The colony of *Eucelatoria rubentis* was derived from material collected and maintained in culture at the USDA laboratory in Tifton, Georgia. Both colonies were reared at Clemson University

in *Helicoverpa zea* (Boddie) and *Heliothis virescens* (F.), according to methods described by Nettles et al. (1980) and Reitz and Adler (1991).

Larvae for taxonomic study were dissected from singly-parasitized hosts (*H. zea*), boiled in lactic acid, slide-mounted (cephalopharyngeal skeletons in lateral view) in Euparal®, and examined with an Olympus BH-2 compound microscope fitted with an ocular micrometer. Voucher material is deposited in the Clemson University Arthropod Collection.

Methods for interspecific mating trials follow those of Reitz and Adler (1991). Briefly, 2-day old, virgin males were placed in a plexiglass arena (15 × 10 × 10 cm). Five minutes later, one newly eclosed heterospecific female was introduced into the arena and all interactions were recorded. Additional heterospecific groups were held together for up to 5 days, after which females were dissected in physiological saline and examined for the presence of sperm in the spermathecae and embryonated eggs in the common oviduct.

To determine the suitability of various species of Noctuidae as hosts, feeding-stage fifth instars (≥ 20) of each noctuid were presented to individual 2-wk old females, or larvae were placed in cages containing 50–100 adult flies for 30–120 min. Larvae were then returned individually to 31-ml plastic cups containing a suitable meridic diet and inspected daily for the presence of parasitoids.

RESULTS AND DISCUSSION

Larval taxonomy.—The three larval instars of each species can be distinguished on the basis of size and development of the cephalopharyngeal skeletons (Fig. 1). The posterior spiracles are well-developed, with three slits each, only in the third instar (Fig. 1). Instar 1 has three blunt hooks surrounding the posterior spiracles, whereas instar 2 has two pairs of hook plates around the posterior spiracles; hook plates are absent in third instars. All instars have 12 bands of

microspines around the body, although the terminal (12th) band, surrounding the posterior spiracles, is weakly developed.

Second and third instars of the two species can be distinguished most readily by the development of the dorsal cornu of the tentoropharyngeal sclerite, which is significantly greater in height and more massive anteriorly in *E. rubentis* than *E. bryani* (Table 1, Fig. 1). Additionally, third instars of *E. bryani* have significantly more papillate openings (range: 3–5 each) at the apex of the anterior spiracles than do those of *E. rubentis* (2 or 3) (Table 1). The posterior spiracles of the third instar (Fig. 1D) are similar, although the sclerotization between spiracular slits tends to be darker in *E. rubentis*. First instars cannot be separated reliably.

Interspecific matings.—Under laboratory conditions, these two species are reproductively isolated. For both species, the emergence pattern is protandrous, females are monogamous, and males are polygamous. The courtship behaviors of *E. rubentis* are similar to those described for *E. bryani* (Reitz and Adler 1991). Males of both species mounted heterospecific females and initiated courtship. These interspecific courtships continued in a manner similar to that described for *E. bryani* by Reitz and Adler (1991), with males of both species attempting intromission with heterospecific females. However, based on examination of spermathecae after mating attempts, sperm transfer did not occur and these females did not produce embryonated eggs ($n = 8$ for *E. bryani* male × *E. rubentis* female; $n = 6$ for *E. rubentis* male × *E. bryani* female).

Host specificity.—We successfully reared *E. bryani* from *H. zea*, *H. virescens*, and *Heliothis subflexa* (Guenée). Attempts to rear *E. bryani* from other Noctuidae including *Anticarsia gemmatilis* Hübner, *Pseudoplusia includens* (Walker), *Spodoptera ornithogalli* (Guenée), and *Trichoplusia ni* (Hübner) were unsuccessful. *Eucelatoria bryani* has been reared from field-collected *A. gemmatilis*, *Spodoptera frugiperda*

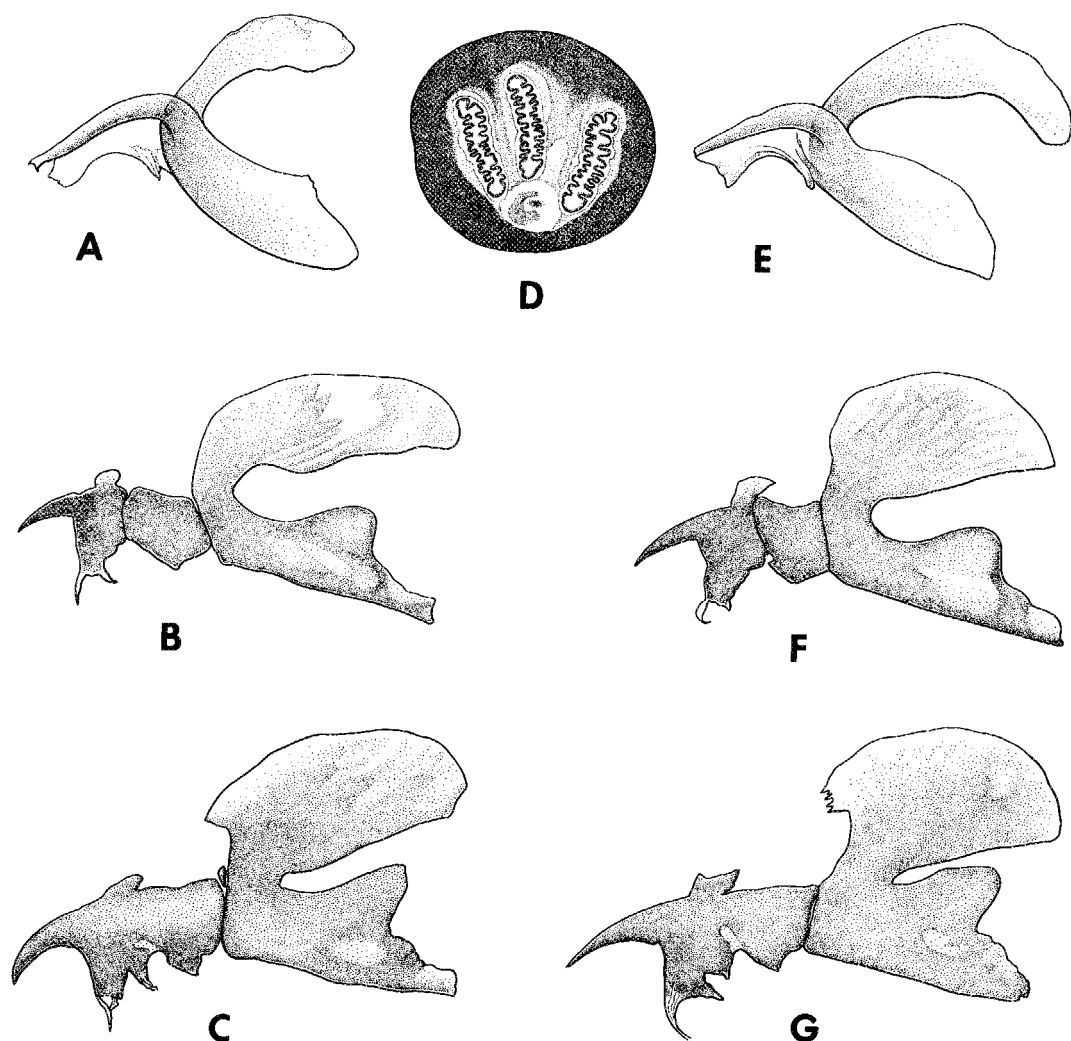


Fig. 1. Larval features of *Eucelatoria*. A–C, *E. bryani*, cephalopharyngeal skeletons (lateral). A, First instar. B, Second instar. C, Third instar. D, *E. bryani*, posterior spiracle of third instar. E–G, *E. rubentis*, cephalopharyngeal skeletons (lateral). E, First instar. F, Second instar. G, Third instar.

(Smith) and *T. ni*, but these host records are rare compared with those from *H. zea* and *H. virescens* (Butler 1958, Sabrosky 1981).

In contrast, we successfully reared *E. rubentis* from *H. zea*, *H. virescens*, and *H. subflexa*, *A. gemmatilis*, and *P. includens*. Based on field collections, host species for *E. rubentis* include these species as well as 12 other species of Noctuidae and Pyralidae (Arnaud 1978, Sabrosky 1981). The basis for this interspecific difference in host range appears to be the failure of *E. bryani* fe-

males to oviposit in hosts. Nettles (1980) found *E. bryani* females were attracted to *H. virescens* but not to *Spodoptera eridania* (Cramer) or *Estigmene acrea* (Drury).

Females of both species deposit progeny in proportion to host size (Reitz 1996a), but progeny of *E. bryani* tend to be smaller and develop more rapidly than those of *E. rubentis*. Because of its more rapid development, *E. bryani* is a superior intrinsic competitor compared with *E. rubentis* when parasitizing *H. zea* (Reitz 1996b).

Table 1. Selected larval features, mean \pm SE, n , of *Eucelatoria bryani* and *E. rubentis*. Means with different letters are significantly different for each character within each instar (t-test; $P < 0.005$); other values are not significantly different ($P > 0.05$); n.o., not observed.

Species	Instar	Cephalopharyngeal Skeleton, Length ¹	Dorsal Cornu, Height ²	Number of Anterior Spiracular Openings
<i>E. bryani</i>	1	0.16 \pm 0.004 (10)a	0.02 \pm 0.001 (10)a	n.o.
<i>E. rubentis</i>	1	0.18 \pm 0.011 (8)a	0.02 \pm 0.002 (7)a	n.o.
<i>E. bryani</i>	2	0.33 \pm 0.008 (10)a	0.07 \pm 0.002 (10)a	n.o.
<i>E. rubentis</i>	2	0.34 \pm 0.007 (6)a	0.09 \pm 0.002 (6)b	n.o.
<i>E. bryani</i>	3	0.67 \pm 0.013 (11)a	0.16 \pm 0.003 (11)a	3.7 \pm 0.17 (11)a
<i>E. rubentis</i>	3	0.76 \pm 0.020 (10)b	0.19 \pm 0.006 (10)b	2.6 \pm 0.17 (10)b

¹ Tip of mandible to posterior of dorsal cornu in mm.

² Greatest height in mm.

Potential for biological control.—Given that both species are facultatively gregarious (Reitz 1996a) and have relatively high fecundities (Gross and Rogers 1995, Reitz and Adler 1995), both species could be important biological control agents. Knipling (1992) considered *E. bryani* to be one of the most important parasitoids of *H. zea* and *H. virescens* and proposed a plan for using *E. bryani* to suppress these host populations. The possibility exists for using *E. rubentis* in a similar program against other pest noctuids. While host specificity is a desirable attribute of biological control agents (e.g. Greathead 1986), polyphagy is not necessarily a detrimental attribute, if a polyphagous parasitoid attacks several sympatric pest species (Ehler and van den Bosch 1974). The potential for using augmentative releases of *E. bryani* and *E. rubentis* would be further enhanced with continued refinement of *in vitro* rearing methods (Bratti and Nettles 1992). No one biological control agent is likely to manage a pest population completely, but if used properly, *E. bryani* offers an excellent opportunity to help manage *H. zea*, and *E. rubentis* offers a similar opportunity to help manage several other noctuid pests.

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LITERATURE CITED

- Arnaud, P. H., Jr. 1978. A host-parasite catalog of North American Tachinidae (Diptera). United States Department of Agriculture Miscellaneous Publication 1319, 860 pp.
- Bratti, A. and W. C. Nettles. 1992. *In vitro* rearing of *Eucelatoria bryani*—improvements and evaluation of factors affecting efficiency. *Entomologia Experimentalis et Applicata* 63: 213–219.
- Butler, G. D. 1958. Tachinid flies reared from lepidopterous larvae in Arizona, 1957. *Journal of Economic Entomology* 51: 561–562.
- Ehler, L. E. and R. van den Bosch. 1974. An analysis of the natural biological control of *Trichoplusia ni* (Lepidoptera: Noctuidae) on cotton in California. *Canadian Entomologist* 106: 1067–1073.
- Greathead, D. J. 1986. Parasitoids in classical biological control, pp. 290–318. *In* Waage, J. and D. Greathead, eds., *Insect Parasitoids*. Academic Press, London.
- Gross, H. R. and C. E. Rogers. 1995. Reproductive biology of *Eucelatoria rubentis* (Diptera: Tachinidae) reared on larvae of *Helicoverpa zea* (Lepidoptera: Noctuidae). *Biological Control* 5: 285–289.
- Knipling, E. F. 1992. Principles of insect parasitism analyzed from new perspectives. Washington, United States Department of Agriculture, Agriculture Handbook 693, 337 pp.
- Nettles, W. C., Jr. 1980. Adult *Eucelatoria* sp.: Response to volatiles from cotton and okra plants and from larvae of *Heliothis virescens*, *Spodoptera eridania*, and *Estigmene acrea*. *Environmental Entomology* 9: 759–763.
- Nettles, W. C., Jr., C. M. Wilson, and S. W. Ziser. 1980. A diet and method for the *in vitro* rearing

- of the tachinid, *Eucelatoria* sp. Annals of the Entomological Society of America 73: 180–184.
- Reitz, S. R. 1996a. Development of *Eucelatoria bryani* and *Eucelatoria rubentis* (Diptera: Tachinidae) in different instars of *Helicoverpa zea* (Lepidoptera: Noctuidae). Annals of the Entomological Society of America 89: 81–87.
- . 1996b. Interspecific competition between two parasitoids of *Helicoverpa zea*: *Eucelatoria bryani* and *Eucelatoria rubentis*. Entomologia Experimentalis et Applicata 79: 227–234.
- Reitz, S. R. and P. H. Adler. 1991. Courtship and mating behavior of *Eucelatoria bryani* (Diptera: Tachinidae), a larval parasitoid of *Heliothis* spp. (Lepidoptera: Noctuidae). Annals of the Entomological Society of America 84: 23–30.
- . 1995. Fecundity and oviposition of *Eucelatoria bryani* (Diptera: Tachinidae), a gregarious parasitoid of *Helicoverpa zea* and *Heliothis virescens* (Lepidoptera: Noctuidae). Entomologia Experimentalis et Applicata 75: 175–181.
- Sabrosky, C. W. 1981. A partial revision of the genus *Eucelatoria* (Diptera: Tachinidae), including important parasites of *Heliothis*. United States Department of Agriculture, Technical Bulletin 1635, 18 pp.
- Wood, D. M. 1987. Tachinidae, pp. 1193–1269. In McAlpine, J. F., ed., Manual of Nearctic Diptera. Volume 2. Research Branch, Agriculture Canada, Monograph 28: 675–1332.